

## REMARKS

There are 14 claims pending in the application comprising claims 1-14. Dependent claims 9 and 11-14 have been amended to rectify the dependencies of these claims. No new matter is added in connection with these amendments so that they all should be entered at this time.

In the Office Action, claims 9 and 10-14 are rejected under 35 U.S.C. 112, second paragraph. In response, claims 9 and 11-14 have been amended to depend from independent claim 8 to remove the lack of antecedent basis for "the system". However, with respect to claim 10, it is believed that the Office Action mistakenly specified this claim to lack antecedent basis, as this claim is dependent from independent claim 8, which is drawn to a system.

In the Office Action, claims 1-14 are rejected as being obvious over U.S. Patent No. 6,384,917 to Fradkin (hereinafter "Fradkin"). Applicants submit that claims 1-14 are allowable in view of Fradkin at least because Fradkin does not show or suggest all the features of claims 1-14.

Fradkin discloses a method and apparatus for matching tooth color, in which a light source is provided with an illumination lens and a relay lens to direct light to illuminate a measurement point in a chosen zone (region) of a tooth selected in a patient's mouth. Light reflected from the tooth is passed through a third lens which focuses the reflected light simultaneously on three detectors. The three detectors produce an output signal representing the color related to the measurement point. The process is repeated for a total of three zones on the tooth, developing a color vector set for comparison with a predetermined color vector set to match the closest color vector, allowing the tooth color to be classified as corresponding to one of the colors in the Master Teeth Set.

The present invention is an improvement over Fradkin in that it analyzes color characteristics of selectively identified regions of the patient's tooth in order to determine the shade of the tooth for the selectively identified regions and not just analyzing color characteristics of a point representing a region, as is the case in Fradkin (*see, e.g., Fradkin, abstract*). In the system and method of the present invention, the color content of an entire region is processed before comparison to the information in the database (*see, e.g., claim 1*)

"At step 50, certain color characteristics for the different categories of regions (selectively identified by the operator) may be generated based on the image information and based on how the user divided the image information (e.g., captured from the image based on where two parallel lines dividing the patient's tooth into the incisal, central, and cervical regions were placed). The color characteristics may for example be the Red, Green, and Blue (RGB) characteristics of each region." (Par. 43 of the published application)

By analyzing the color content in a region rather than a point representing a region, the determination of tooth shade becomes much more accurate, simply because a point representing a region fails to capture the vast color information in a region that is made of hundreds of points.

The color characteristics of a region of the patient's tooth are compared with corresponding color characteristics for tooth shades in the database that is associated with that same region.

"At step 54, tooth shades are identified by region based on information in a database of tooth shade information (e.g., a database such as that described in connection with FIG. 3) and based on the color characteristics that are generated. A tooth shade for a region of a patient's tooth may be identified by comparing some or all of the color characteristics that were generated for that region of the patient's tooth with corresponding color characteristics for tooth shades in the database that are associated with that same region (e.g., regions that spatially correspond)." (Par. 45 of the published application)

In contrast to the present invention, Fradkin analyzes color characteristics of a randomly selected point representing a region (zone) of the patient's tooth.

"In a preferred embodiment of the invention, a light source is provided with an illumination lens and a relay lens. A light aperture at the end of a probe directs the light from the light source to illuminate a measurement point in a chosen zone of a tooth selected in the patient's mouth." (Fradkin, Col. 2, lines 1-5)

In the same manner, the color characteristics of a randomly selected point representing a region (zone) of the Master teeth is analyzed to obtain Master teeth set.

"In the space of these normalized coordinates each zone of each Master Tooth is represented by a single point ( $H_{sub.n.sup.(i)}$ ,  $S_{sub.n.sup.(i)}$ ,  $I_{sub.n.sup.(i)}$ ).sup.(i) and a radius vector  $\rho_{sub.i}$ , as represented in block 76. All zones of all Master Teeth undergo a segmentation technique performed in block 75 in which the zones are represented by corresponding points ( $H_{sub.n}$ ,  $S_{sub.n}$ ,  $I_{sub.n}$ ).sup.(k) and radius vectors  $\rho_{sub.k}$ . The maximum number of points (M) is equivalent to forty-eight corresponding to three zones per tooth of the sixteen teeth in the Master Teeth Set." (Fradkin, Col. 4, lines 35-44)

The classification of the patient's tooth shade is facilitated by determining the color vector closest to the predetermined set of color set (Master teeth set).

"[O]nce the chosen zone coordinates of a tested tooth ( $H_{sub.n}$ ,  $S_{sub.n}$ ,  $I_{sub.n}$ ) are measured, the corresponding point P in the ( $H_{sub.n}$ ,  $S_{sub.n}$ ,  $I_{sub.n}$ ) space is determined, as shown in FIG. 6. This allows the distances  $d_{sub.p.sup.(k)}$  from P to each one of points 1,2,3 . . . M to be calculated and the affiliation of the measurement point P with regard to color is based on the minimal distance  $d_{sub.p}$ ." (Fradkin, Col. 4, lines 45-50)

In this processing, the color characteristics of a point representing a region of the patient's tooth is compared to the entire Master teeth set (1,2,3, ... M) and not just to the regions corresponding to color characteristics for tooth shades that is associated with that same region, as is the case in the present invention.

In summary, the device disclosed in the method and apparatus of Fradkin facilitates tooth color determination through reflectivity measurement of a point (i.e. point processing). This point processing is performed on both the color characteristics of a region of a patient's tooth as well as the color characteristics of the Master teeth set. Tooth shade

determination is accomplished by comparing the tested region with the entire Master teeth set containing all regions (point-by-point comparison).

The present invention presents a number of significant advantages over Fradkin. First, the color characteristic of a region is determined based on the color information processing of the entire region (i.e. ensemble processing). The ensemble processing provides much better color representation for a region than the point processing associated with Fradkin. As discussed above, a region is generally made from several hundred points and naturally the color characteristics of each point can vary significantly within the region.

Second, in contrast to Fradkin, the tooth shade determination is accomplished by comparing the region of the tested tooth with corresponding color characteristics for tooth shades in the database that are associated with that same region (i.e. region-by-region comparison). The region-by-region comparison provides much more accurate results than point-by-point comparison technique employed in Fradkin. It should be noted that the regions in a tooth are distinctly different from each other and hence the motivation for separation of a tooth into regions. The region-by-region comparison guarantees that the characteristic of the search domain is inherently similar to the tested region. Consequently, the results at the very least belong to the same class as the tested region. Additionally, by limiting the search domain to the region that corresponds to the tested region, the search time is reduced in comparison to methods such as those of Fradkin which search the entire search domain. For example, if there are three regions then search time is reduced by 1/3, assuming linear decrease in search time. Thus, region-by-region comparison is more efficient and more accurate than the point-by-point comparison method of Fradkin.

Third, tooth shade results computed by the method of the present invention are convergent. For a selected region of a tooth, the results of the tooth shade evaluation will be the same if the evaluation process were to be repeated. Ensemble processing ensures a consistent result for a given region by considering the entire region in its processing rather than just a single point within a region, as is the case for point processing of Fradkin. Generally, the ensemble processing is not susceptible to variation in a repeated trial. The point processing, however, can have significant variation in its results unless the same exact point for reflectivity measurement is chosen. Accordingly, the convergent characteristic of the ensemble processing provides for more consistent results for tooth shade evaluation.

Fourth, the operational characteristic of the present invention is much simpler than that of the method and apparatus presented in Fradkin. For example, the device of Fradkin requires the probe to have actual contact with the tooth surface for reflectively measurement (*see*, Fradkin Col. 5, lines 1-4). This method presents a serious hygiene issue which requires a resolution consistent with health regulation governing dental hygiene operations. For example, one remedy may be to cover the probe with a discardable transparent shield during treatment of each patient. This resolution suffers from the fact that the shield can itself alter the reflectivity measurement. Another remedy would be to employ a disinfectant to clean the lens and the surrounding area of the probe after each use. The disinfectant can leave significant smudge on the surface of the outside lens which will require careful examination by the operator. Unless the operator ensures that the lens is sufficiently clean, which given the size of the probe and lens can be difficult, the results of the reflectivity measurement can be invalid due to impact of residual smudge. The method and apparatus of the present invention does not require the image capturing tool to have contact with the tooth surface, and as such, it is simpler in operation and the does not suffer from the limitations of the device of Fradkin.

It is therefore evident that the invention as disclosed in the application has many features that are significantly advanced over the prior art and specifically over Fradkin. Accordingly, the invention as described and claimed is not a mere specification of the nuts and bolts of the process disclosed by Fradkin, as argued by the Office Action in the first paragraph on page 3.

In the office action, it is argued that "one of ordinary skill in the art would have readily found obvious the selection of a particular zone with a mouse moving a box representing the zone over the electronic image to the desired zone". First, the operator controlled region selection is a manifestation of the fact the present invention capture information on all regions of a tooth at the same time (i.e. simultaneously), and as such requires means to allow the operator to partition these regions for regional analysis. Thus, this feature is not necessarily an advanced feature of this invention but an unavoidable consequence of method of capturing tooth information.

Second, Fradkin would have been well aware various means for image acquisition available at the time of the invention, given the inventors substantial knowledge of operation of optical devices, as demonstrated in the discloser. The inventors would have also been well

aware of the repetitive steps associated with the determination tooth shade for all regions of a tooth, as these steps are necessary and not extraneous for such determination.

Third, in light of the significant advantages of the present invention, such as, for example, greater accuracy, consistency, efficiency, and simplicity of operation, Fradkin would have certainly wanted to incorporate these indispensable features in the disclosure, if such a disclosure was an obvious to one ordinary skill in the art.

With respect to the argument presented in the Office Action regarding Fradkin use of CCD, the arguments presented above are not affected by Fradkin use of CCD, as the tooth shade processing and procedures disclosed by Fradkin is exactly the same irrespective of the ability of the system to record the tooth color information for every point selected by the operator.

For the foregoing reasons, applicant submits that all of the current claims are patentable over the cited art and respectfully requests reconsideration and an early indication of allowance. Should the Examiner not agree with Applicants' position, then a personal or telephonic interview is respectfully requested to discuss any remaining issues in an effort to expedite the eventual allowance of the application.

Respectfully submitted,

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Date

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